

“SPHENOID”

A new mnemonic for preoperative radiological evaluation of transsphenoidal approach surgery



- ✓ **S**epta
- ✓ **P**neumatization extension and recesses
- ✓ **H**amberger classification
- ✓ **E**ndonasal structures
- ✓ **N**eurovascular structures
- ✓ **O**nodi cell
- ✓ **I**nvasion Cavernous Sinus
- ✓ **D**ehiscences



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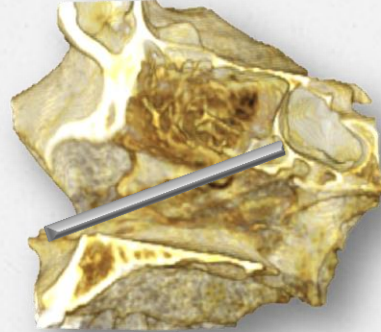
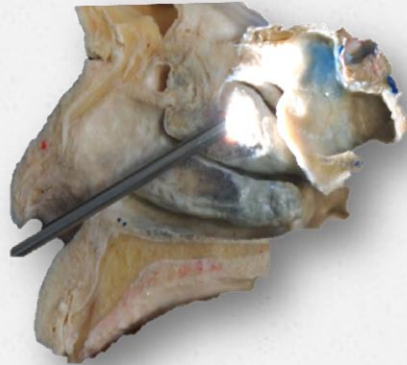
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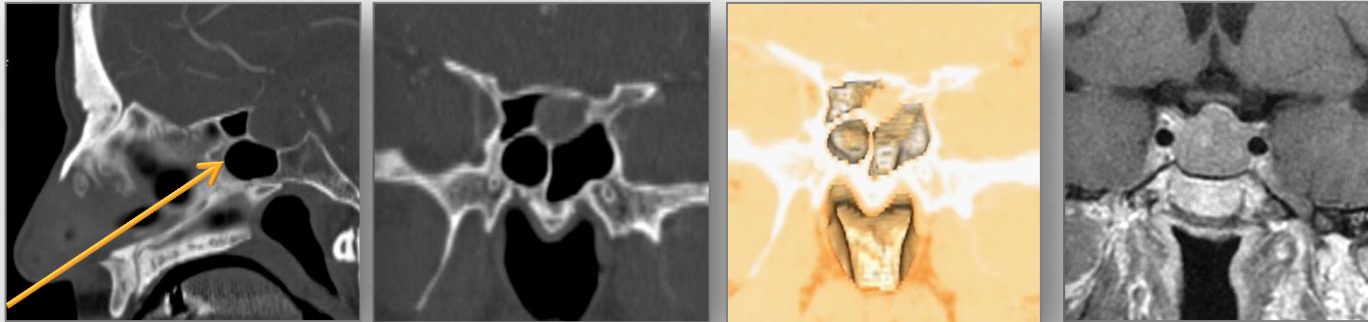
Introduction

- The endoscopic endonasal transsphenoidal approach for pituitary tumors and sellar lesions has always been a challenge due to complex anatomy of this area and the important neurovascular structures around the sella.



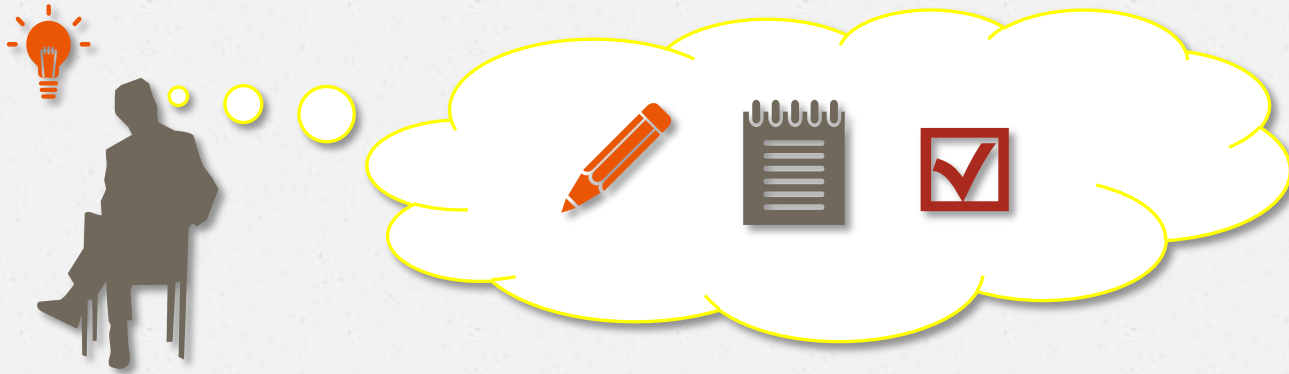
Introduction

- **Imaging techniques**, especially computed tomography (CT) images, provide the surgeon with information about the main anatomical structures and variants which knowledge is essential for planning the surgery, avoiding complications or failure of the endoscopic surgery.



Introduction

- Our goal was to propose an easy **mnemonic rule** that encompass all these structures to systematically apply when reporting preoperative examinations.



Methods

- By considering the different anatomic structures and variants that radiologists should evaluate when reporting a preoperative CT scan of patients before an endoscopic endonasal transsphenoidal approach, we constructed the acronym **SPHENOID** with the initials of major items to be considered.



SPHENOID

Results

- Radiological evaluation for planning endonasal transsphenoidal surgery should always consider the following aspects, and their initials form the word **SPHENOID**.

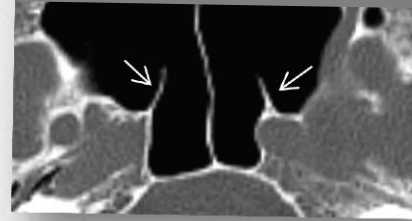
- ✓ **S**eppta
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S

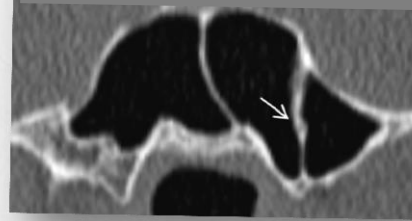
Septa

- Pattern of sphenoidal septation and the location and number of intrasinus septa are important.
- The bilateral sphenoidal sinuses are separated by an intersinus septum.
- The intersinus septum may be located on the midline (38%), on the right (20.6%) or the left (21.7%), off the midline.
- Accessory septa may also subdivide the sphenoid sinus.
- Variation:
 - 1 Septum (48%)
 - 2 Septa (48%)
 - 3 Septa (4%)
- In 85% of cases, septa insert into the bony bulges over the optic nerve or the internal carotid artery (paraclival or parasellar ICA).

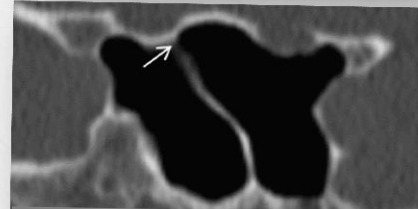
Septa insertion over paraclival ICA



Septum containing the vidian nerve



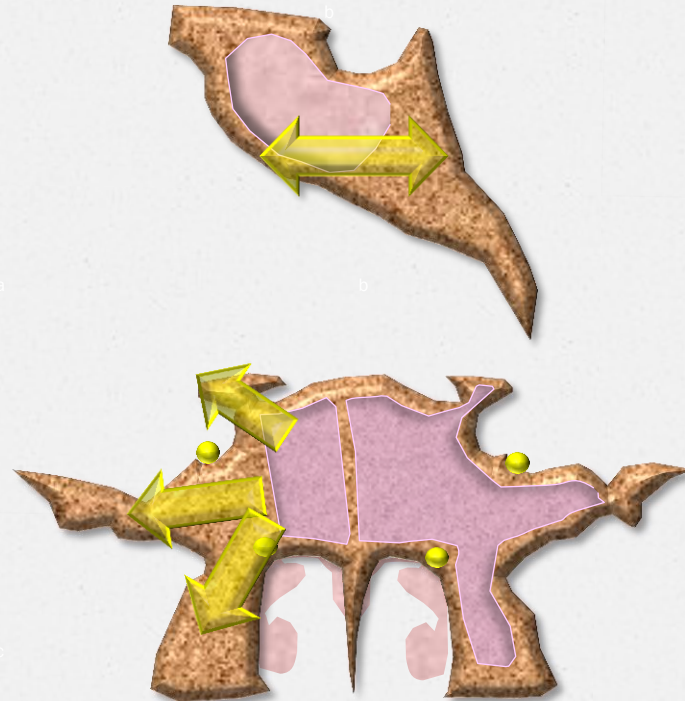
Septa insertion over optic nerve



P

Pneumatization extension and recesses

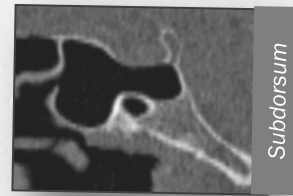
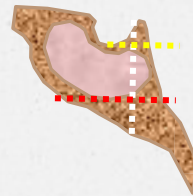
- Extension of sphenoid bone pneumatization greatly determine the suitability of the endonasal transsphenoidal approach.
- Greater pneumatization allows extended surgical approaches by providing natural corridors to access skull base lesions and produces recesses and bony prominences of neurovascular structures, which are separated by a thin layer of bone or may be dehiscent.
- Sphenoid recesses according pneumatization direction are:
 - **Posterior** → Clival recess (dorsum, subdorsum, occipital, and dorsum-occipital types)
 - **Anterior** → Ethmoidal and septal recesses
 - **Lateral** → Lateral recess (lesser wing, greater wing, pterygoid, and full lateral types)



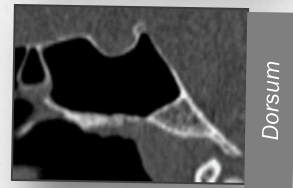
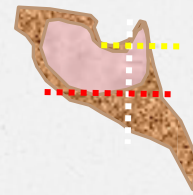
P

Pneumatization extension and recesses: **Clival type**

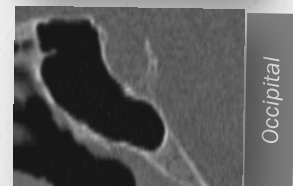
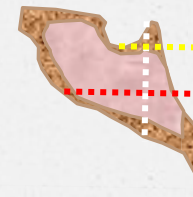
- The clival type of sphenoid pneumatization is subdivided into **dorsum**, **subdorsum**, **occipital**, and **dorsum-occipital types**, depending on the direction of pneumatization, and may facilitate access to the dorsum, posterior clinoid processes, petrous apex, entire clivus down to the anterior lip of the foramen magnum and odontoid process, and anterior brainstem and adjacent cisterns
- Subdorsum** → Sinus extends posterior to a line directed along the posterior wall of the sella (*white line*), but not into the dorsum sellae or into the clivus below the level of the vidian canal.
- Dorsum** → Sinus extends above the line directed along the floor of the sella and into the dorsum sellae (*yellow line*).
- Occipital** → The expansion of the sinus behind the posterior wall of the sella (*white line*) extends inferiorly below the level of the horizontal plane directed along the upper edge of the paired vidian canals (*red line*).
- Combined dorsum- occipital** → The sinus extends superiorly into the dorsum and downward below the horizontal plane directed along the upper edge of the vidian canals.



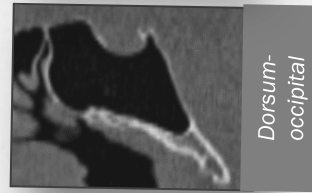
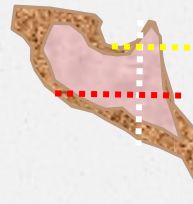
Subdorsum



Dorsum



Occipital

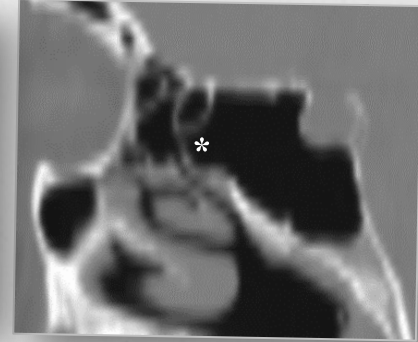
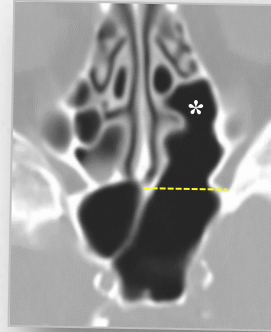


Dorsum-
occipital

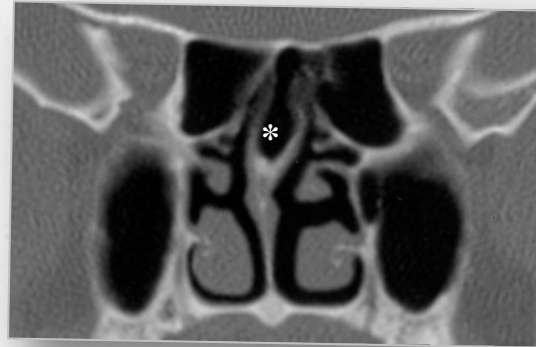
P

Pneumatization extension and recesses: **Anterior**

- **Ethmoidal recess** → is an anterolateral protusion or anterior extension of the sphenoidal sinus to a transverse line crossing the sphenoid sinus side of the sphenoid crest to form an anterior recess facing the maxillary sinus (*dashed line*).
This type of sinus extends anteriorly above the sphenopalatine artery and foramen.
- **Septal recess** → is formed by pneumatization of the posterior portion of nasal septum or vomer, called **sphenovomerine bulla**.



Ethmoidal recess

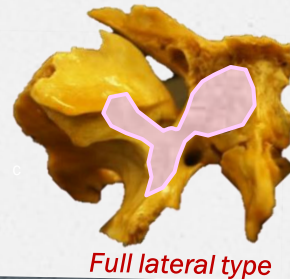
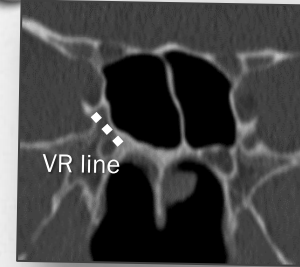
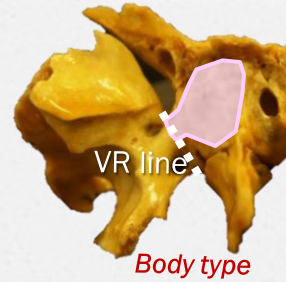


Septal recess = sphenovomerine bulla

P

Pneumatization extension and recesses: **Lateral**

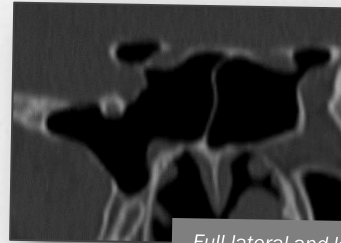
- The lateral type of pneumatization is subdivided into greater wing, pterygoid process, and full lateral types, permits approaches to the cavernous sinus, middle fossa, and petrous apex.
 - Body type:** The pneumatization is confined to the body of the sphenoid bone and does not extend beyond a drawn line that crosses the medial edge of the foramen rotundum and vidian canal (called the VR line). Lateral recess is not present.
 - Greater wing type:** The lateral wall of the sinus extends laterally beyond VR line into the greater wing.
 - Pterygoid type:** The lateral wall of the sinus extends inferolaterally beyond VR line into the pterygoid processes
 - Full lateral type:** The lateral wall of the sinus extends beyond VR line into the pterygoid processes and greater wing.
 - Lesser wing type:** The sphenoidal sinus extends through the optic strut and into the anterior clinoid process, forming the medial (m) and lateral (l) opticocarotid recesses. This provides an easier surgical corridor to the lateral suprasellar area.



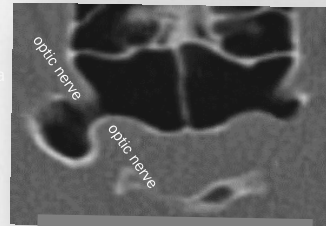
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Pneumatization extension and recesses: **Lateral**

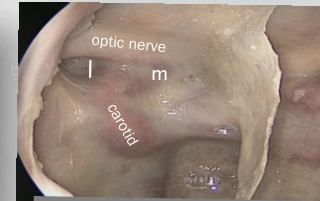
- The lateral type of pneumatization is subdivided into **greater wing**, **pterygoid process**, and **full lateral types**, permits approaches to the cavernous sinus, middle fossa, and petrous apex.
 - Body type:** The pneumatization is confined to the body of the sphenoid bone and does not extend beyond a drawn line that crosses the medial edge of the foramen rotundum and vidian canal (called the **VR line**). Lateral recess is not present.
 - Greater wing type:** The lateral wall of the sinus extends laterally beyond VR line into the greater wing.
 - Pterygoid type:** The lateral wall of the sinus extends inferolaterally beyond VR line into the pterygoid processes
 - Full lateral type:** The lateral wall of the sinus extends beyond VR line into the pterygoid processes and greater wing.
 - Lesser wing type:** The sphenoidal sinus extends through the optic strut and into the anterior clinoid process, forming the **medial (m)** and **lateral (l)** **optiocarotid recesses**. This provides an easier surgical corridor to the lateral suprasellar area.



Full lateral and lesser wing types



Lesser wing type



Lateral and medial
optiocarotid recesses



Full lateral type

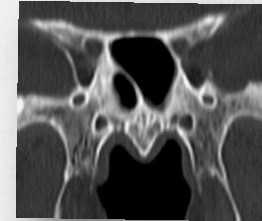
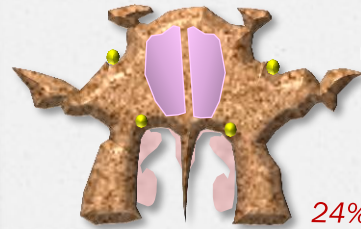


Lesser wing type

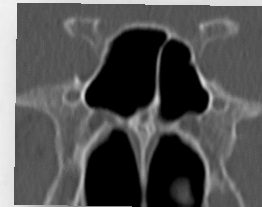
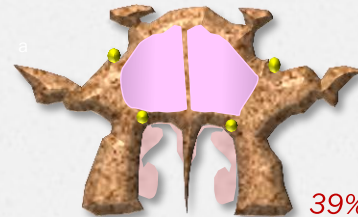
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Pneumatization extension and recesses: **Lateral**

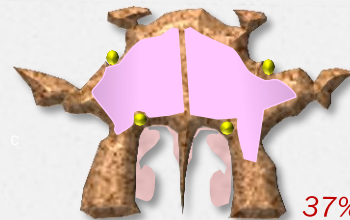
- New anatomic classification schemes include a simple classification of lateral sphenoid sinus pneumatization in the coronal plane, taking in consideration the vidian canal (VC) and the foramen rotundum (FR) as anatomic landmarks.
- This classification divides pneumatization in 3 types:
 - Type I = previdian:** pneumatization extends from the midline to the medial edge of VC. Pterygoid recess is completely absent, neither VC or maxillary nerve protrusions are identifiable inside the sphenoid sinus, covered by 2 mm of bone.
 - Type II = prerotundum:** pneumatization extends to the lateral edge of FR. Pterygoid recess is partially pneumatized. VC is identified at the floor of the pterygoid recess, and the maxillary nerve prominence is partially recognized at the superolateral aspect of the recess. In this case, the paraclival ICA is easily identified, and less drilling is required
 - Type III = postrotundum:** pneumatization extends lateral to the FR, so both the vidian canal and V2 branch protrude into the sphenoidal sinus. The pterygoid recess is extensively pneumatized, extending into the pterygoid body and into the greater wing of the sphenoid bone.
- These types have surgical implications for the endonasal approach to the middle cranial fossa with less or more drilling of bone needed for surgical access.



I. Previdian



II. Prerotundum

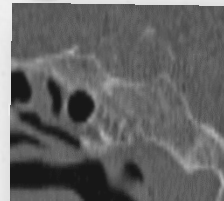


III. Postrotundum

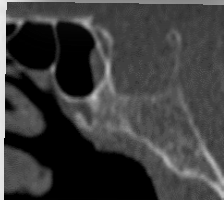
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Hamberger classification

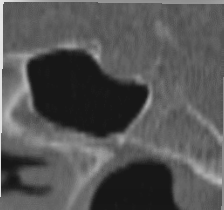
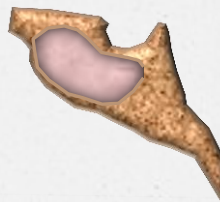
- The traditional classification by Hamberger et al and Hammer and Radberg describes three types of sphenoid pneumatization in adults, according to the proximity of the aerated cavity to the sellar floor:
 - Conchal type (<1%):** pneumatization does not extend into the body of the sphenoid bone. Its anterior wall is separated from the sella turcica by approximately 10 mm of cancellous bone. This type requires more drilling of the bone to reach the sellar floor.
 - Presellar type (7%):** pneumatization is situated in the anterior sphenoid bone and does not penetrate beyond the anterior sellar wall.
 - Sellar type (most common):** the sphenoidal sinus is well pneumatized with bulging of the sellar floor into the sinus.
 - Incomplete (57%):** sinus extends posteriorly below the sella.
 - Complete (36%):** sinus extends to posterior clival margin, forming a clival recess. This type is the most favorable for transsphenoidal surgery because the anterior sellar wall and sellar floor typically measure less than 1 mm in thickness.



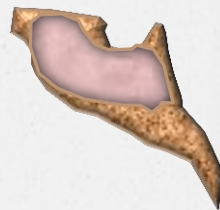
Conchal



Presellar



Incomplete
sellar

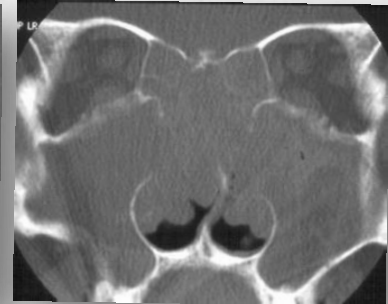
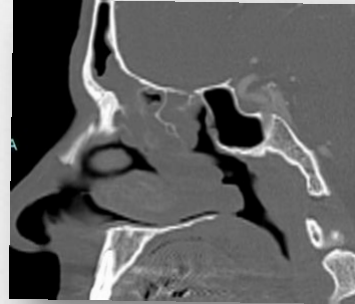


Complete sellar

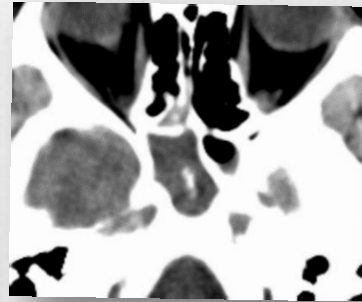
E

Endonasal structures

- Anatomic endonasal variations (eg, *septal deviation*, *spina septi*, and *concha bullosa*) and inflammatory conditions (*polyps*) could pose difficulties during the nasal phase of endoscopic surgery and radiologist must report them.



Sinonasal polyposis



Sphenoid aspergillosis

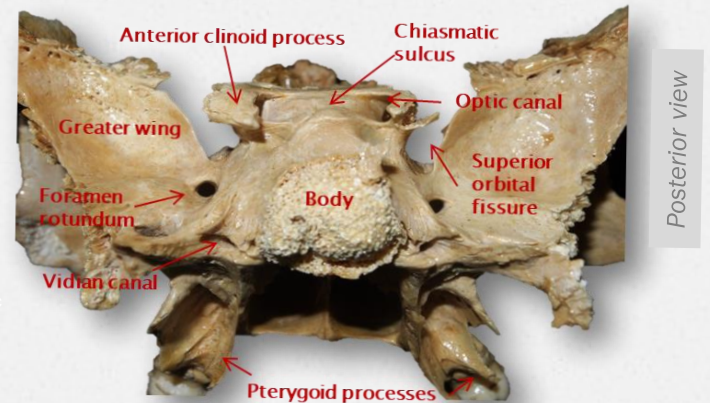
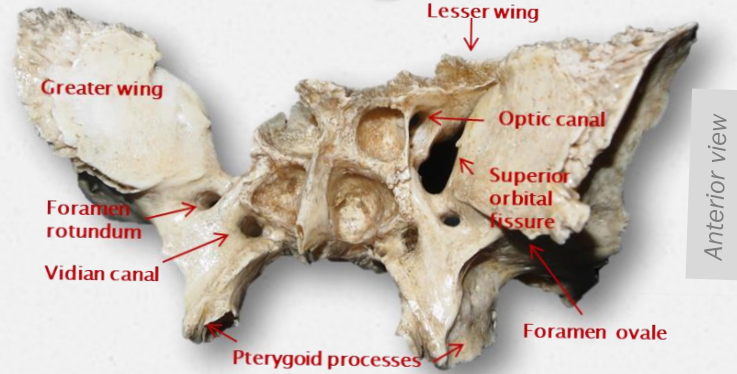


Left spina septi, septal deviation and right paradoxical middle turbinate

N

Neurovascular structures

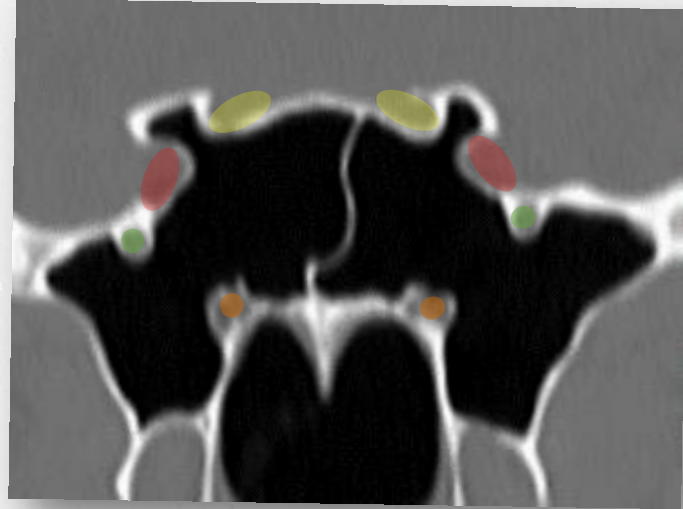
- The sphenoid bone has a number of important neurovascular canals producing bony prominences depends on the sinus pneumatization:
 - Superior orbital fissure**, through which the oculomotor, trochlear, abducens, and ophthalmic nerves pass, is formed on its inferior and lateral margins by the greater wing and on its superior margin by the lesser wing.
 - Optic canals** are situated above and separated from the superomedial margin of the superior orbital fissure by the optic strut, a bridge of bone extending from the lower margin of the base of the anterior clinoid process to the body of the sphenoid.
 - Pterygoid (vidian) canal** courses from anterior to posterior through the junction of the pterygoid process and sphenoid body.
 - Foramina rotundum and ovale**, which contain the V2 and V3 branches of the trigeminal nerve, respectively.
 - Foramen spinosum** are located from anterior to posterior, near the junction of the sphenoid body and greater wing.



N

Neurovascular structures

- The sphenoid bone has a number of important neurovascular canals producing bony prominences depends on the sinus pneumatization:
 - **Superior orbital fissure**, through which the oculomotor, trochlear, abducens, and ophthalmic nerves pass, is formed on its inferior and lateral margins by the greater wing and on its superior margin by the lesser wing.
 - **Optic canals** are situated above and separated from the superomedial margin of the superior orbital fissure by the optic strut, a bridge of bone extending from the lower margin of the base of the anterior clinoid process to the body of the sphenoid.
 - **Pterygoid (vidian) canal** courses from anterior to posterior through the junction of the pterygoid process and sphenoid body.
 - **Foramina rotundum and ovale**, which contain the V2 and V3 branches of the trigeminal nerve, respectively.
 - **Foramen spinosum** are located from anterior to posterior, near the junction of the sphenoid body and greater wing.

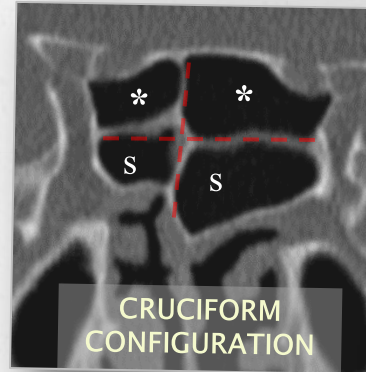
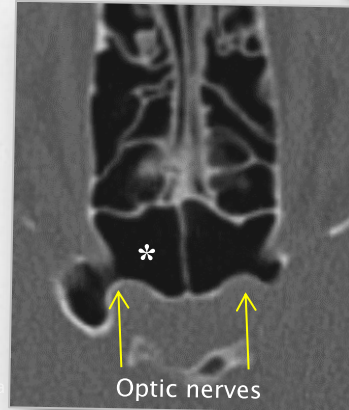


Optic canals and nerves
Intracavernous carotid arteries
Foramina rotundum with maxillary nerves
Vidian canal and nerves

O

Onodi cells

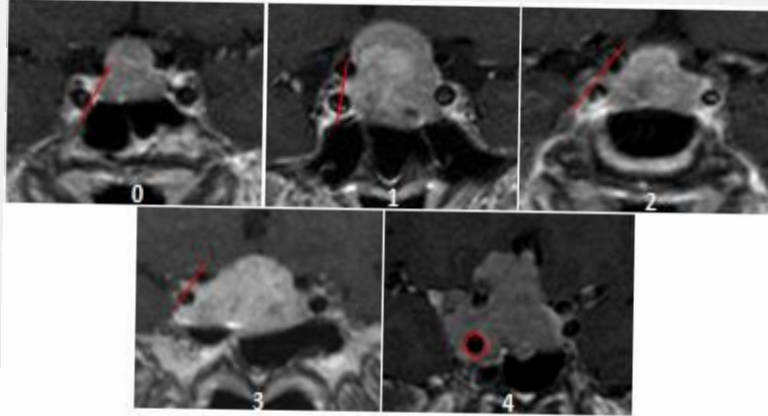
- **Onodi or sphenoethmoidal cells (*)** are an abnormal pneumatization of a posterior ethmoidal cell projecting over and/or lateral to the sphenoid sinus (S).
- They are found in up to 8%-14% of patients, and may also extend into the anterior clinoid processes in 6%-13% of cases.
- On coronal CT images, a helpful clue to the presence of these air cells is a horizontal or cruciform septum. A horizontal septation represents downward displacement of the anterior wall of the sphenoidal sinus by a superiorly overriding Onodi cell, and a **cruciform configuration** results from bilateral Onodi cells associated with a midline intersphenoidal septum.
- Relationship to the **optic nerve** and **internal carotid artery** and the possibility of damaging these structures in surgery.
- Their presence can cause the surgeon to become disorientated regarding the usual anatomy, which can be catastrophic during surgery because behind the posterior wall of Onodi cells, the surgeon will encounter the middle cranial fossa instead of the expected sphenoidal sinus.



I

Invasion Cavernous Sinus

- Invasive growth of pituitary adenomas has been reported in surgical series in up to 40% of cases.
- Parasellar invasiveness into cavernous sinus (CS) structures is still one of the most important **prognostic factors** for incomplete resection in nonfunctioning pituitary adenomas and failure to achieve remission in functioning pituitary adenomas, increasing morbidity and mortality in surgery
- It is not always possible to tell if there is CS invasion, but there are signs to look out for:
 - Encasement of ICA in more than 2/3 of its perimeter
 - Tumor extension lateral to the top of ICA (12 o'clock)
 - Interposition of abnormal soft tissue between lateral wall of the CS and the ICA
 - Knosp-Steiner grade 3-4



Knosp- Steiner classification of cavernous sinus invasion

It is based on the extent of lateral tumor growth in relationship to a tangential line drawn between the intracavernous and supracavernous internal carotid arteries on coronal MR images. The classification describes five grades of invasion, ranging from 0 to 4.

Study data from *Knosp et al* show that identification of a tumor that crosses the intercarotid line (grade 2 or higher) on a coronal MR image is highly predictive of cavernous sinus invasion identified at surgery. Conversely, patients with grade 0 or 1 invasion at MR imaging displayed no definitive cavernous sinus invasion at surgery.

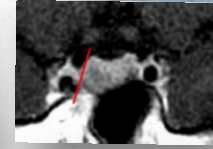
Moreover, *Knosp et al* noted that degree of invasion was directly related to tumor size.

I

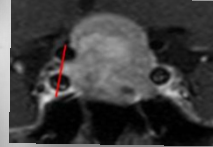
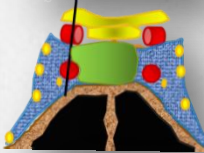
Invasion Cavernous Sinus

- Several classification proposals have tried to better predict the degree of invasion of cavernous sinus in pituitary adenomas and add information to the Knosp classification from the scope of actual surgery techniques.
- Micko et al. first proposed a **subdivision of Knosp 3** grade into adenomas invading CS **superiorly (3a)** that had a much lower invasion rate, and those invading CS **inferiorly (3b)** with a higher invasion rate and potentially more complications.
- This is probably explained by the existence of a stronger medial wall at the superior compartment than at the inferior compartment.
- For this reason, the distinction between grades 3a, 3b, and 4 is of importance for prediction of adenoma invasion and surgical treatment considerations.

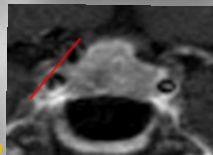
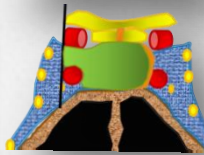
Knosp 0
No risk of CS invasion



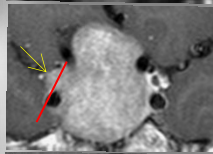
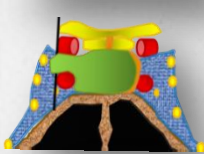
Knosp 1
Low risk of CS invasion
(1,5%)



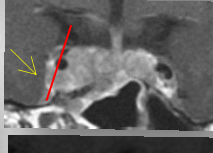
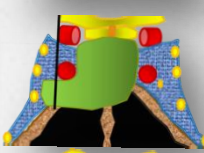
Knosp 2
Low risk of CS invasion
(10%)



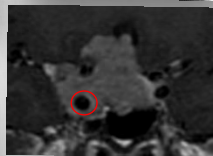
Knosp 3a (sup comp)
More risk of CS invasion
(26,5%)



Knosp 3b (inf comp)
High risk of CS invasion
(70,6%)



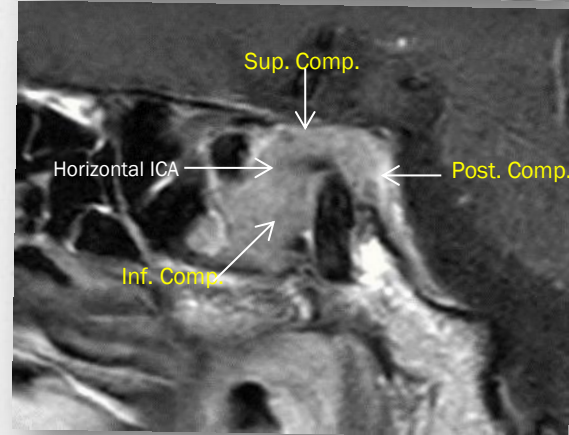
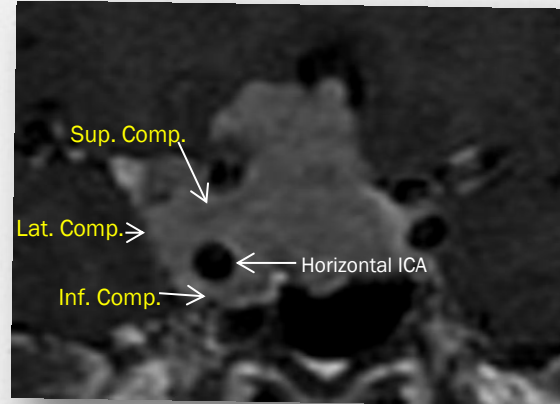
Knosp 4
CS invasion (100%)



I

Invasion Cavernous Sinus

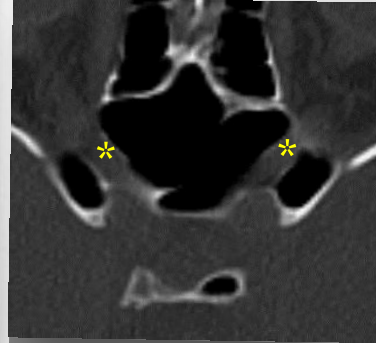
- Miranda et al. also developed an **anatomy-based** classification of tumors invading cavernous sinus.
- They proposed 4 cavernous sinus compartments based on their spatial relationship with the cavernous internal carotid artery and dividing in **superior, posterior, inferior, and lateral**, each of them with its particular boundaries and dural and neurovascular relationships.
- Residual tumor rates were higher for the lateral extension compartment, for this reason, even in cases in which there is compression without true invasion of the CS, they remark the importance of identifying the potentially involved compartments in preoperative imaging studies.
- Note that superior compartment is equivalent to grade 3a proposed by Micko et al and inferior compartment to grade 3b.



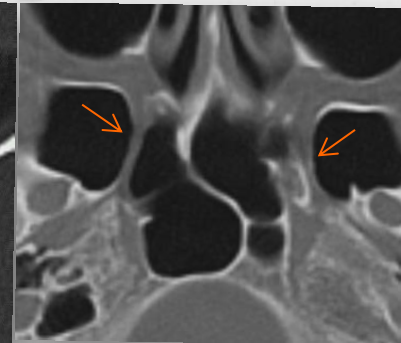
D

Dehiscences

- Extensive pneumatization of the sphenoid sinus (clival, full lateral or lesser wing pneumatization) or Onodi cells may produce recesses and bony prominences of neurovascular structures, sometimes separated by a thin layer of bone or dehiscence.
- Carotid canal prominence to the sphenoid sinus wall is present up to 35% and dehiscences up to 25%.
- Optic canal prominence is present up to 32% and dehiscences up to 10%.
- DeLano et al. classified the relationship of the optic canal to the sphenoidal and ethmoidal sinuses into four types, according to the degree of protrusion.
- Surgeon must always remember that optic canal and internal carotid artery may not be well protected and are liable to injury.



Optic nerves dehiscences in lesser wing pneumatization



Maxillary nerves dehiscences in full lateral pneumatization



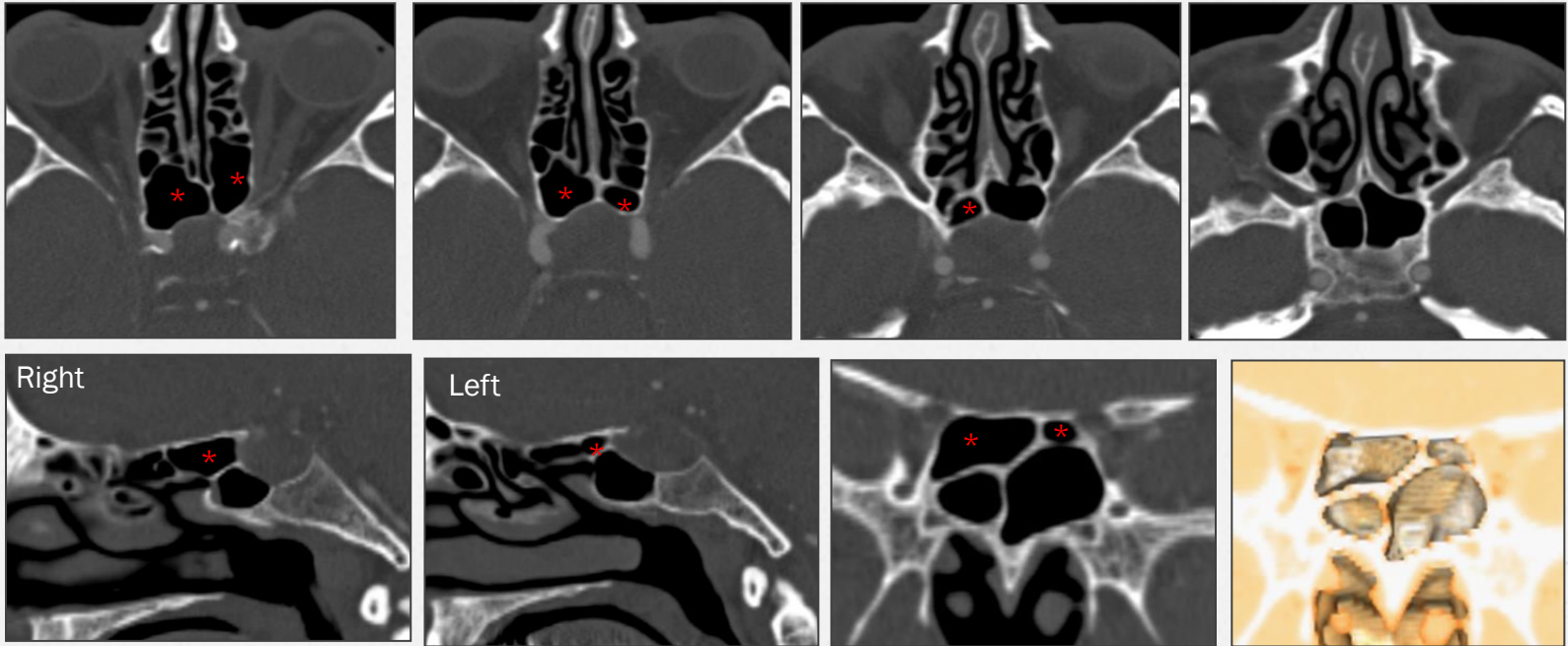
Internal carotid dehiscences in clival pneumatization (dorsum)

Discussion

- Mnemonic are learning tools to completely remember important information.
- They should be considered not only a learning resource, but also a working tool.
- By systematically applying the “**SPHENOID rule**” radiologists can easily remember all the aspects that a report of a preoperative CT scan should include in patients before endoscopic endonasal transsphenoidal approach surgery, as we show in next slide with a case example.

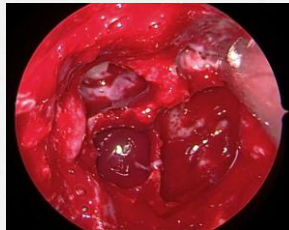
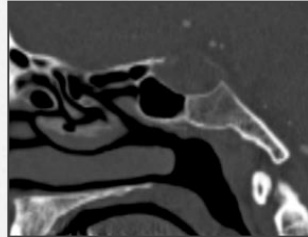
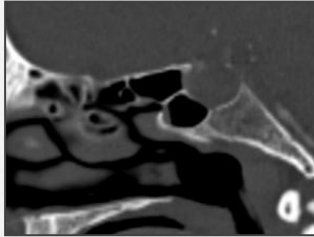
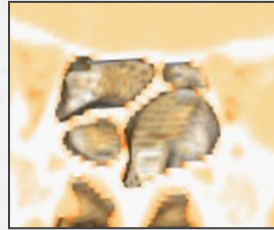
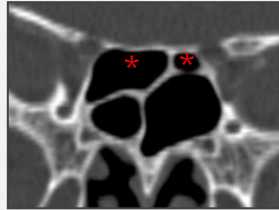
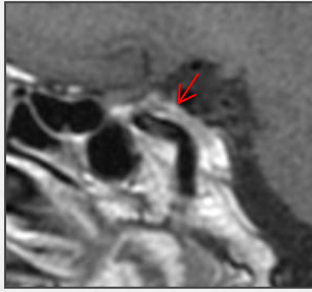
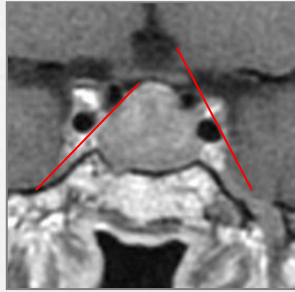
Case example

73 years old man with occasional headache



Case example

73 years old man with occasional headache



Pathology: **Gonadotroph pituitary macroadenoma**

- ✓ **S**epa: no accessory septa
- ✓ **P**neumatization extension/recesses: previdian right, postvidian left
- ✓ **H**amberger classification: incomplete sellar bilateral
- ✓ **E**ndonasal structures: no abnormalities
- ✓ **N**eurovascular structures: ok
- ✓ **O**nodi cell: Yes, bilateral
- ✓ **I**nvasion Cavernous Sinus: Knosp 0 right; Knosp 2 left; Suprasellar, superior and posterior compartments affected
- ✓ **D**ehiscences: No

Conclusion

- Using the proposed **“SPHENOID”** mnemonic facilitates the systematic assessment of the anatomic structures and landmarks to take into account in the endonasal transsphenoidal approach.



SPHENOID

- ✓ **S**eptra
- ✓ **P**neumatization extension and recesses
- ✓ **H**amberger classification
- ✓ **E**ndonasal structures
- ✓ **N**eurovascular structures
- ✓ **O**ndi cell
- ✓ **I**nvasion Cavernous Sinus
- ✓ **D**ehiscences

